MACHINE SHOP NOTES.

Part I.

FOR THE USE OF STUDENTS IN SHOPWORK.

Massachusetts Institute of Technology.

BY

R. H. SMITH.

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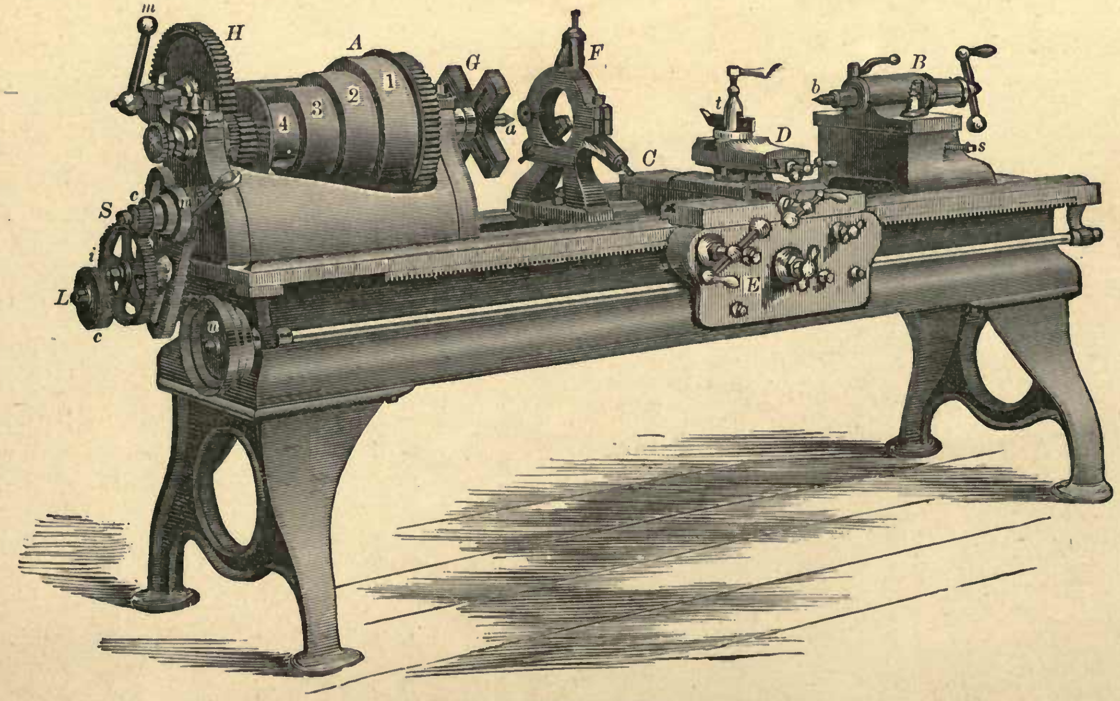

ENGINE LATHE.

A Headstock.	*E* Apron.	*S* Stud or feed spindle.	*c, c* Change gears.	*t* Tool post.
B Tailstock.	*F* Centre or steady rest.	*L* Lead screw.	*i* Intermediate gear.	*s* Set-over screw for tailstock.
C Carriage.	*G* Face plate.	*a* Live centre.	*n, n* Belt-feed cones.	*m* Handle for throwing in back gears.
D Slide rest.	*H* Back gears.	*b* Dead centre.	1, 2, 3, 4, 1st, 2d, 3d, 4th speeds on headstock cone.	

MACHINE SHOP NOTES.

GENERAL DIRECTIONS.

1. Each student will be given a lathe and check number; the former designates the lathe he will use during his course, and the latter his shop number or number of his tool box. The lathe number is placed on the left-hand corner of the lathe.

2. Lathe Cupboard. — Each engine lathe cupboard contains the following tools: A 12″ scale, 3″ scale, centre gauge, large and small outside calipers, inside calipers, stop for thread cutting, drift pin for removing live centre, two small parallel blocks (used when boring), wrenches for lathe, change gears for screw cutting, and (for all Putnam lathes) a stud used when cutting left-hand threads.

3. Tool Box. — Each tool box contains a right-hand diamond point, a right-hand side, and a round-nosed tool, a monkey-wrench, a centre punch, a scratch awl, a small oil stone, some chalk, and five checks on a ring, each having the same number as the tool box.

The tool boxes are kept in the tool room, there being one for each student, marked clearly with his shop number and used only by him.

4. Beginning Work. — On giving his shop number to the attendant at the tool room window, the student will receive his tool box at the beginning of each exercise.

Before beginning work, each student should examine his lathe cupboard and tool box to see if everything is in place; should anything be lacking, report it at once to the instructor in charge. A failure to do this will make the student responsible for anything found missing at the close of the exercise.

5. Use of Checks. — Each of the five checks is numbered the same as the tool box, and they should be used for extra tools taken from the tool room, one check being deposited for each tool taken out. Tools obtained by check should be returned, well cleaned, immediately after having finished using them, the deposited checks being received in exchange for the tools. Students will be held responsible for the loss

or breakage of any tool while it is in their charge. In asking for a tool at the tool room, be sure and state clearly what you wish to use it for.

6. Closing Work. — At the close of each exercise return all borrowed tools and the tool box with everything in its place. Stamp your work plainly, whether it be finished or unfinished, and put it in the pigeon hole of the work case having your shop number. See that everything about the machine you have been using is in proper place, and thoroughly clean the machine with brush and waste. The brush may be found on the outside of the lathe cupboard, and waste may be obtained at the tool room. All oily waste is to be thrown into a sheet-iron box provided for it. In putting away work, be sure and oil the finished surfaces to prevent their rusting.

7. Oil Cans. — The nickel-plated oil cans, on brackets in different parts of the shop, contain machine oil which is only to be used for lubricating purposes; those found at each lathe contain lard oil to be used for various purposes, such as drilling, tapping, screw cutting, polishing, etc., but not for oiling machinery.

8. Machinery. — Before using any machine, the student should understand its general construction in order that he may intelligently use it and avoid accidents. If at any time in doubt, the student should question the instructor.

Before starting, see that the machine is well oiled, and that the moving parts are free; the latter can usually be determined by moving the driving belt by hand.

9. Drawings. — Drawings of all pieces are kept in the tool room, where they may be obtained when wanted.

10. Stock. — On receiving a piece of rough stock, see that it will finish to the dimensions given on the drawing, or that it is of such size that, when turned or planed to within $\frac{1}{64}''$ of finish size, all the skin will be removed from the finished parts. Should the stock not be large enough to finish to dimensions, or should there be any flaw in it, report at once to the instructor.

When possible, remove the skin from all finished parts of a piece before finishing; except in squaring the ends of turned work, where the piece may be finished, as to length, before removing the skin from the cylindrical surface.

ENGINE LATHE.

11. Most of the engine lathes in the machine shop have eight speeds, — four with the back gears in, and four with the gears out. They are all screw cutting, and are supplied with hand and power longitudinal

feed. All have hand cross feed; and some have both hand and power cross feed.

Those lathes supplied with a belt feed have only three changes, by means of step pulleys. Those supplied with gear feed may have any range of feed within the combinations of the change gears. For a fine feed, place a small driving gear on the "stud," or spindle, and a large following gear on the splined "lead screw"; an intermediate gear, or idler, being arranged between them, to communicate motion from one to the other. To increase the feed, put a larger gear on the stud. Care should be taken in setting these gears, so that the teeth will mesh properly.

12. Lathe Centres. — The "centres" are classed among the most particular parts of a lathe, as upon their truth depends that of all work done upon them. It is therefore essential that they be kept in good order and perfectly true. The centre in the headstock spindle, or head spindle, is called the *live centre*, and the one in the tailstock spindle, or tail spindle, the *dead centre*.

Each live centre has a line on its shank parallel with its axis; to insure that the centre shall always be put back in the same position relative to the spindle, when removed, this line is made to intersect another line drawn on the end of the live spindle.

To test the truth of the live centre, move the tailstock up the lathe bed until the dead centre is close to the live centre, run the lathe at its highest speed; the eye can then quickly perceive whether the live centre runs true or not. This is also an approximate method for setting the dead centre in line with the live centre.

Lathe centres and centre-reamers, or countersinks, are made to fit the 60° centre gauge (*A*, Fig. 3), found in the lathe cupboard. This insures ample bearing of the centred piece; thus preventing undue wear, and preserving the truth of the centres.

It is not absolutely necessary that the live centre be perfectly true when "squaring up" or "roughing out" work; but it should be perfectly true when taking a finishing cut. In any case, it is best to have the centre true.

The dead centre is usually hardened; the live centre may or may not be hardened, usually not.

TRUING CENTRES.

13. Remove the dead centre, by running the spindle back in the tailstock until the screw pushes the centre out; then anneal, by heating it to a cherry red and allowing it to cool slowly. Remove the live centre by a drift pin, which can be found in the lathe cupboard. (In lathes which have hollow spindles, the live centre has to be driven out with a

rod, which can be found at the side of the lathe.) Great care should be taken to properly clean the shank of the centre and the hole in the spindle. Place the dead centre in the headstock spindle; then, with a centre tool (a broad-nosed tool, employed for this purpose only), turn it to fit the centre gauge.

The cutting edge of the tool should be at the same height as the line of centres.

The live centre is trued in the same manner as the dead centre.

File the dead centre a very little with a "dead smooth" file, harden, and draw to a straw color, but do not file or harden the live centre.

14. Centre-Grinding Machine. — To operate upon hardened centres, a centre-grinding machine is employed; a driving wheel is bolted to the lathe face plate; a stand, set over the tool post and held in place by the set screw, carries at its top the overhead belt pulleys, and at its base the emery wheel and spindle. A feed lever is pivoted on the end of the emery wheel spindle, by means of which the emery wheel may be traversed along the lathe centre. By the use of this machine the dead centre may be trued up without having to anneal it.

15. Setting Centres on Line. — To have a lathe turn perfectly straight, the centres must be on line. If the dead centre has been set over to turn taper, and it be desired to set it to turn straight again, place a cylindrical bar that is true on the centres; adjust a pointed tool to make a light mark on the end of the bar (next to the live centre) when the carriage is traversed; then, without moving the cross feed, take the bar out of the lathe, and run the carriage until the tool is near the dead centre; put the bar in the lathe again with the marked end next to the dead centre. The tool should now leave, when traversed, a similar mark on the bar.

It consumes a vast amount of time to go through this operation every time it is required to set a lathe to turn straight. To save this time, two zero lines are put on the rear end of the tailstock. When these lines coincide, the lathe will turn practically straight. The "Brown & Sharpe" and "Pratt & Whitney" lathes will turn straight when the sides of the tailstock are flush. Always unclamp the tailstock before moving the adjusting screws; do not bring these screws up hard, but just enough to prevent any side movement of the spindle.

In Fig. 1 is shown a device for setting the tailstock of a lathe to turn parallel work. *A* is a bar of cast iron about $\frac{3}{4}''$ square, its length being about the radius of the face plate of the lathe. *B* is a small hole drilled through *A* and countersunk at *C* and *D*, as shown in the figure. *E* is an adjusting screw supplied with a divided circle at *F*, and an index bar at *G*, which enables settings to be readily made.

The method of using the above device is as follows: Move the tail-

stock up the lathe bed near the live centre and adjust the dead centre approximately. Place the countersink *C* on the live centre, and *D* on

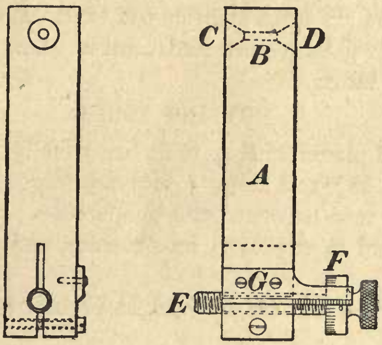

Fig. 1.

the dead centre, and clamp both tailstock and spindle. Turn the screw *E* in, by means of the thumb screw, until it will just touch the face plate, and notice its reading. Now turn the screw back about one revolution. Then turn the live spindle and the device one-half a revolution, and again turn the screw in until it will just touch the face plate: if it reads the same as before, the tailstock is right, and the lathe will turn parallel; but if it does not, the tailstock must be adjusted until the same reading is obtained on opposite sides.

To get good results with the foregoing or any device, the live centre must be perfectly true.

SPEED LATHE.

16. The speed lathe, or hand lathe, is a high-speed machine without automatic feeds, usually arranged with four changes of speed, and is used for drilling, turning on centres, chuck turning, chucking, and polishing. These lathes are fitted with slide rests, T rests, chucks of various sizes, drill rests, drill sockets, chucking tools, slide rest tools, etc. Tools not at the lathe can be procured at the tool room.

By the use of this lathe small work of any kind can be turned, chucked, or faced, without the aid of an engine lathe, and with greater rapidity.

This lathe is also very useful for small drilling, polishing, and brass work, on account of its high speed.

Hand tools are used in connection with the slide-rest tools for rounding edges and ends and turning irregular forms.

The centres are similar to those of an engine lathe, and are trued up with a hand tool called the "graver."

It is well to remember that work revolving at a high speed should be kept free on the centres, and that the dead centre should be frequently oiled. As work gets warm, it will expand and bind on the centres, and if you are not watchful, will twist off the point of the dead centre, thus spoiling both work and centre. This is also liable to happen on an engine lathe.

CUTTING TOOLS.

17. Lathe and planer cutting tools are usually made of a grade of cast steel known as "tool steel"; they are forged, filed up to the required form, and then hardened and tempered.

An outside tool is employed on external, and an inside tool on internal, surfaces.

A right-hand tool will cut from right to left, a left-hand tool from left to right.

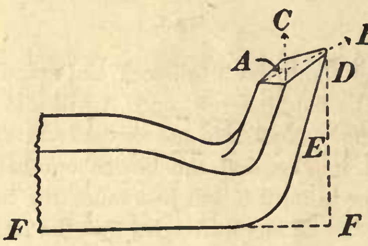

Fig. 2.

Fig. 2 represents a right-hand diamond point tool; *A* is termed the top face; its inclination in the direction of the arrow *B* is its front, and its inclination in the direction of the arrow *C* its side rake, these angles being considered with relation to the bottom plane of the tool *FF*. The angle of the bottom edge or face *E* with the line *FD* is the clearance or the bottom rake.

It is well to remember that nearly all the keenness should be placed on the top face of a tool; the office of the bottom face is to support the cutting edge; therefore the amount of clearance, or bottom rake, should only be sufficient to make the tool clear well and not ride on the work.

It is obvious that various combinations of front and side rake may be given to a tool; for heavy, deep cuts, a maximum of side rake may be used to advantage; and for finishing, a maximum of front rake.

For small work, where the cuts are not heavy and the tool is employed for both roughing out and finishing, it is an advantage to give the top face of the tool a combination of front and side rake of about equal proportions.

Tools employed on machinery steel or wrought iron should have top rake enough to make them keen; for cast steel or any hard metal the

rake should be reduced so that the tool will stand a reasonable time without regrinding. Tools with top rake can be employed to advantage on cast iron; but if the metal is hard, the amount must be small.

The difference between tools employed on iron and steel, and those employed on brass, is, that the latter do not require any top rake; for if too keen, they will chatter, thus giving the surface of the brass a mottled appearance.

To farther illustrate the foregoing, a complete set of lathe and planer tools is kept in the tool room. Each tool is ground to the angles suitable for the purpose for which it is designed; that is, to angles that have been found by experience to give good results. These tools are to be used as models, and the student can occasionally compare his tools with them.

When grinding a tool, hold it firmly in the hands, this being the only way to get good results. It is not always desirable to bear hard on the grindstone or emery wheel, since too great pressure on the stone, or especially on the emery wheel, will cause the tool to become heated so as to draw its temper.

18. Holding Tools.—A tool should be so fastened that its cutting edge is as near the tool post as circumstances will permit, the object being to avoid its springing and to prevent as far as possible its giving way to the cut.

SPEED AND FEED FOR LATHES.

19. Cutting speed as applied to machine tools means the number of feet of cutting performed by the tool in a given time.

Feed as applied to machine tools means the thickness of the shaving taken by the tool, measured in the direction of the feed.

There is no part of machine-tool work in which a greater variation is possible than in the speed and feed of lathe work; for what would be coarse feed on one piece of work might be fine on another; and what would be high speed on one piece might be slow on another; therefore, we cannot lay down definite rules in all cases, as the nature of the work may render peculiar conditions of speed and feed necessary; however, enough will be said in what follows, and in connection with each class of work, to form a basis which will enable the student to determine for himself what speed and feed is the most advantageous.

The speed and feed of a lathe should be varied according to the nature of the material to be turned. In turning heavy work, time is saved by running slowly and using a coarse feed; on small work, by running at as high a speed as the tool will stand and using a fine feed.

If the material is heavy wrought iron, steel, or cast iron, use slow speed and coarse feed; but if the work is hard, reduce the speed and feed so that the tool will stand a reasonable time without regrinding.

If the work is light and liable to spring, use fast speed and fine feed.

On brass, run at a high rate of speed, unless it is very hard, and always use fine feed.

In boring or inside turning an advantage is gained by running at a reasonable speed, and feeding fine, as there is always more or less spring in all boring tools.

20. Roughing out work is taking off one or more cuts which reduce it to within about $\frac{1}{64}''$ of finished size.

If the cut is very heavy, the tool is liable to draw in as it advances, thus turning the work to a smaller diameter than that it was set for. In turning long and slender pieces which would be liable to spring from the pressure of the tool, a steady rest or back rest is employed to support the work.

In the roughing cut, the object is to remove the surplus metal as quickly as possible, and prepare the work for the finishing cut; therefore, the tool should be set to turn off all the surplus metal whenever the lathe has power enough to drive the cut; and the cutting speed should be as fast as the depth of the cut and tool will permit.

Both for roughing and finishing cuts it is advisable to have the feed as coarse as the conditions will allow.

21. In taking the roughing cut there is no objection to removing the tool to regrind it, but in the case of the finishing cut it is desirable that the tool carry the cut its full length without regrinding, because of the difficulty of again setting the tool to cut to exact diameter.

CENTRING.

22. Place the work in a vise; chip or file the snags off, and rub chalk on the ends: next open a pair of dividers (compass calipers are more convenient) to a distance approximately equal to the radius of the work, and hold one leg firmly against the perimeter of the work, as near the end as possible, while with the point of the other leg a line is marked on the end of the work; perform this operation at four equidistant points. If the dividers are opened more or less than the radius of the work, a small space will be enclosed between these lines; the eye can now quickly and easily locate its centre, where the centre punch may be placed, and a light hammer blow produces the required indentation.

Next place the work between the lathe centres and revolve it to see if it is true enough to turn to size; if so, make a deep indentation with the centre punch to guide the drill.

If the work does not run true enough to turn to size, revolve it with one hand, and hold a piece of chalk with the other (allowing the hand

to rest on some part of the machine), so that the most eccentric part of the work will touch the chalk; with the hammer and centre punch set the hole over toward where the chalk has touched the work; repeat this operation until the work runs true enough.

23. Centre Drilling. — Centre drill with the speed lathe, running the belt on the third speed when using a centre drill of about $\frac{1}{16}''$ in diameter. By the third speed is meant that when the belt is on the third step from the right-hand end of the cone.

The centre drill is revolved by the live spindle, and held in either a small chuck or socket.

Place one end of the work on the dead centre and support the other end with the left hand on a line with the centre drill; with the right hand screw out the tailstock spindle. The work will then be forced upon the revolving drill, thus drilling the hole.

Be careful in drilling to allow no weight to rest upon the drill; if oil is needed, the drill should be freely supplied, using the right hand for that purpose.

Always use oil in drilling and countersinking steel, wrought iron, and brass; but never use oil on cast iron.

It is very important during this operation of drilling to screw the tailstock spindle back about two-thirds of the depth of the hole every few seconds, the object being to let the chips get out of the hole and the oil get in. This method renders the drill less liable to be broken in the hole, it often being a very difficult operation to remove from the hole the piece of the drill thus broken.

In screwing the tailstock spindle back, be sure and press the work hard against the dead centre with the left hand, so that it will not fall off and spring or break the drill.

24. Countersinking. — The countersink should have the same angle as the lathe centres.

To countersink, run the lathe at the first speed, and hold the work as in centre drilling, relaxing every few seconds the hold upon the work sufficiently to let it make about a quarter revolution, the object being to make the centre hole true.

In countersinking, the point of the countersink must not be allowed to touch the bottom of the drilled hole, as such contact will break the point, and also change the angle of the hole. It must also be remembered that the centres of all lathe work should be cleared at the bottom, so that the extreme points of the lathe centres will not touch the work and be injured. Therefore, always drill the hole about $\frac{1}{8}''$ below the countersink. The size of the centre holes depends on the size of the finished work and on the cutting pressure of the lathe tools.

Work finishing $\frac{1}{2}''$ or under should have centre holes not larger than

$\frac{1}{8}''$ outside diameter when squared to length; that finishing $1''$ and $1\frac{1}{2}''$ should have the diameters $\frac{3}{16}''$ and $\frac{1}{4}''$ respectively. For work finishing between these sizes, and larger, judgment should be used, taking into account the appearance of the work and the pressure on the lathe centres.

After the student is familiar with the above process of centring, the centring machine can be used.

25. The centring machine is employed to centre and centre-drill at one operation, doing the work much quicker than can be done by hand. The chuck is universal, the jaws moving simultaneously. After carefully centring, drilling, and countersinking, we come to the squaring of the ends.

PLACING WORK ON CENTRES.

26. With a piece of waste wipe the centre holes and centres. This must be remembered; for if any chips or grit are left on the centres or in the centre holes, the work will run out of true.

Fasten a "dog" on one end of the work, the tail of the "dog" projecting over the end far enough to catch in the slot in the face plate of the lathe.

Place the end with the "dog" attached on the live centre; with the left hand under the other end, press the work against the live centre to prevent it from falling off, and hold it on a line with the dead centre, allowing the little finger to project by the end to guide the centre into the hole; with the right hand slide the tailstock to position, and clamp it, leaving space enough to work the slide rest freely for squaring the end. Always put oil on the dead centre or in the centre hole, and never allow the centre to become dry; then gently screw out the tailstock spindle until there is no end movement to the work, and clamp the spindle.

A very common method of determining whether work is tight on the centres or not is to judge by the force required to partially rotate it. Be very careful not to get the work tight on centres. When taking a heavy cut the work will get warm and expand, and thus bind on the centres; therefore, the student should be watchful, and under such conditions should relieve and oil the dead centre quite frequently. If this is neglected, it is liable to cause the destruction of both work and centre.

SQUARING CAST IRON.—CARD 101-A.

27. Always "square up" the ends of the work to the length that is specified on the drawing before turning off the cylindrical surface.

For squaring up work, set the point of the tool at the same height as the point of the centres.

To remove the skin on the end, a small round-nosed tool is employed,

and the cut is carried from circumference to centre; then a side tool is employed with a top rake of about 20°. Set the cutting edge of the tool at an angle of about 10° with the end of the work, so that it will cut deepest at the point, enabling it to carry a cut from centre to circumference. To square up the opposite end, reverse the work in the lathe.

Rough out both ends, leaving the piece $\frac{1}{64}''$ longer than the given length. Before taking the finishing cut on the ends, see that the centre holes are right and of uniform size (for Card 101 they should be about $\frac{3}{16}''$ in diameter), as they should not be countersunk after the work is squared to length. The ends of the work should be flat; test them with the edge of a scale.

Before taking the finishing cut on any piece of work, see that the tool has a sharp edge.

Speed for Squaring. — Card 101-A. — For the roughing cuts use the second speed, and for the finishing cut, the third speed, "back gears out."

STRAIGHT TURNING, CAST IRON. — CARD 101-A.

28. For parallel work the lathe centres must stand on the same line.

In order to turn a piece of work from end to end, it is necessary to reverse it in the lathe. Always place a piece of copper or brass under the set-screw of the "dog" on turned work.

Select a right-hand diamond-point tool, with a top rake of about 20°, and the point slightly rounded; set the shank of the tool at about right angles to the work, and the point above the centre sufficiently to make it cut well, but not enough to allow the bottom face of the tool to rub against the work.

Set the calipers $\frac{1}{64}''$ larger than the given diameter, and turn the work to that size with one roughing cut, provided the lathe will carry it; if it will not, take two roughing cuts, or more if necessary. For the finishing cut, grind the tool, and round its point a little more; then set the calipers to the given diameter, and proceed as on the roughing cut.

In taking a finishing cut, the tool should carry its cut the full length of the work without regrinding, because of the difficulty of resetting the tool to cut to the exact diameter.

29. The following is a method of turning a piece of work from end to end without resetting the tool. Turn up to about one-half the length of the work, stop the feed, then stop the lathe, now take the work out of the lathe and run the carriage back to the dead centre, then reverse the work, and turn off the remainder. If the cross-feed screw has not been moved, or the tool badly worn, both ends of the work will be of the same diameter.

30. Speed for Turning. — Card 101-A. — For the roughing cut, use the second speed, and the third speed for the finishing cut, "back gears out."

Feed for Turning. — Card 101-A. — Use the second feed for the roughing cut, and the finest feed for the finishing cut. For gear feed, use a gear with 49 teeth on the feed spindle, and 98 on the lead screw.

TAPER TURNING AND FITTING. — CARD 101-B.

31. If the taper is given as so much per foot, the distance to set the tailstock over can be readily calculated. For example, if the tailstock is set $\frac{1}{2}''$ out of line, the lathe will turn a taper of one inch to the distance between the centres, whether that be more or less.

If, for instance, the distance between the centres is one foot, the taper will be one inch to the foot; if the distance is two feet, the taper will be one-half inch to the foot, etc.

32. Lathe with Taper Attachment. — It is comparatively simple to turn a taper with a lathe that has a taper attachment, which may be described briefly as follows: Three brackets are bolted to the back of the lathe bed, on the centre one of which is pivoted a bar supplied with a dove-tail groove along its entire length; this bar is also supplied at its ends with circular T slots in which bolts carried by the two other brackets work, which bolts, on being tightened, serve to hold the bar firmly in place. One of the end brackets is graduated so that the bar can be set to turn tapers given in inches per foot. A nicely fitted block, working in the groove of the bar, is attached to the cross slide of the slide rest, and thus the tool is made to move in obedience to the slot in the bar instead of the ways of the lathe, giving the desired taper.

33. Second Method of Taper Turning. — The method to be used with Card 101-B is as follows: Get a cutting-off tool; set its shank at right angles to the work, and its point the same height as the point of the lathe centres; also be sure that the tool will clear itself and not ride on the work. Lay off on the work the length of the taper desired, with the cutting-off tool cut a groove at both ends of the required taper, leaving the diameter of the work at the bottom of each groove just $\frac{1}{32}''$ larger than the finished size of the taper at that point.

Get a taper-setting gauge and set the holder in the tool post at right angles to the work. Place the point of the feeler alternately in each groove, and adjust the tailstock (or taper attachment) until it will touch the bottom of both grooves the same; the lathe will then be set to turn the desired taper, as near as is practicable without resort to trying the work in the taper hole.

Use the same tool in the same manner as in straight turning, with

this exception, that to turn a perfect taper it is absolutely necessary to have the point of the tool at the same height as the points of the lathe centres. It will be found necessary to try the taper in the hole after the first or second cut, in order to exactly adjust the tailstock.

To try a taper in a sleeve, or in its place, make a light chalk mark along it from end to end, smoothing the chalk with the finger; press it into the hole, and partially rotate it; also attempt to vibrate the taper in the sleeve, observing at which end there is the most lateral movement: such movement will indicate how the taper fits. If the fit is correct, the appearance of the chalked line will indicate it, and there will be no lateral movement. Having fitted the taper as nearly as possible with a lathe tool, turn it down to the required diameter, calipering it at the small end: the final cut should be light, *not heavier than* $\frac{1}{64}''$. To finish the taper, chalk a line along it (if it has to be fitted with great accuracy, cover the inside of the hole with a light coat of prussian blue), try it in the hole, noting where it bears; then run it at a high speed, and with an 8″ "mill bastard" file, ease off the parts that bear the hardest, continuing until it fits accurately.

The file strokes should be made under a light pressure, and after every few strokes the cuttings should be cleared from the file with a file card.

As filing tends to destroy the cylindrical truth of the work, the file should only be applied to erase the tool marks.

Speed for Taper. — Card 101-B. — For the roughing cuts, use the second speed, and the third speed for the finishing cut, "back gears out."

Feed for Taper. — Card 101-B. — For the roughing cuts, use the second feed, and the finest feed for the finishing cut. For gear feed, use a gear with 49 teeth on the feed spindle, and 98 on the lead screw.

STRAIGHT FITTING. — CARD 101-B.

34. In a fit of any kind, care should be taken to turn the work so near the diameter of the hole that it will only be necessary to file out the tool marks, in order to make it fit as desired.

This piece is to fit a 1″ cylindrical gauge. The finishing cut should be very light, and should leave the piece so that it will just enter the hole tightly; then running it at the highest speed, erase the tool marks with an 8″ "mill bastard" file, trying it in the hole occasionally to ascertain if the fit is maintained. This should be a close fit.

Use the same speed and feed as on straight turning, Card 101-A.

BOLT TURNING. — CARD 104.

35. The bolt being wrought iron, use lard oil in drilling and countersinking; the countersinks when finished should be about $\frac{1}{8}''$ in diameter.

The turning tools must be very keen edged, should have a top rake of about 35°, and the diamond point very slightly rounded.

Feed. — For the roughing cut, use the second feed, and the finest feed for the finishing cut.

Speed. — For both squaring and turning, use the third speed, with the "back gears out."

Squaring. — "Square up" the outside of the head first; then the opposite end of the bolt to within $\frac{1}{64}''$ of the required length. Now recountersink, if necessary, and take the finishing cuts, first on the outside of the head; then put a "clamp dog" on the head, and take the finishing cut on the opposite end to the exact length.

Turning. — Set the "diamond point" tool around to the left far enough so that you can "turn up" to within $\frac{1}{8}''$ of the head, without having the dog strike the carriage, or having to reset the tool. With the first cut turn the bolt to within $\frac{1}{64}''$ of the required diameter; then "dog on" to the small end, and, with a left-hand side tool, "square up" the inside of the head to within $\frac{1}{64}''$ of the required thickness. As this bolt must fit a $\frac{1}{2}''$ cylindrical gauge, the finishing cut should leave it so that the end will enter the hole tightly. "Square up" the head from the inside to the required thickness.

Filing. — Run at the highest speed, and erase the tool marks with an 8″ "mill bastard" file, trying the bolt in the hole occasionally to ascertain if the fit is maintained. It should be an easy fit, neither tight nor loose.

36. Preparation for cutting the Thread. — Reduce the part of the bolt that is to be threaded $\frac{1}{64}''$ in diameter. Drill and tap a nut; then screw it upon a nut arbor, and "square it up" to the exact thickness.

If all the foregoing operations have been carefully performed, you are now ready to cut the thread.

Tapping. — The diameter of a hole that is to be tapped with a V-thread tap should equal the diameter of the tap at the root of the thread, except on cast iron; then the hole should be large enough to permit only of three-quarters of a full thread.

Oil in Tapping. — Always freely supply a tap with lard oil when used upon wrought iron, steel, cast iron, brass, and composition; but in tapping lead, or any soft metal, oil is not necessary.

Milling Head and Nut. — The bolt head and nut may be "milled" either before or after the thread is cut.

Chamfering. — After the bolt head and nut are "milled" they must be chamfered. To do this, set the side tool at an angle of about 45°, and chamfer the outside corner of the nut and bolt until there is about $\frac{1}{32}''$ flat on the corner of the short diameter.

Filing and Finishing. — After the head and nut are chamfered, the sides should be filed with an 8″ "hand-smooth" file, and finished with No. 90 emery cloth.

SCREW CUTTING.

37. Lathe Dog. — Fasten the dog on the work firmly, for it must not slip. If the face plate of the lathe has more than one slot in it, put a chalk mark near the slot into which you put the tail of the "dog." Whenever the work is taken out of the lathe, it must be put back with the tail of the " dog " in that slot.

Threaded Part. — On bolts, etc., turn the part which is to be threaded $\frac{1}{64}''$ under size.

Recess. — If at the commencement or the termination of a thread it be necessary to cut a recess, use a round-nosed tool for that purpose.

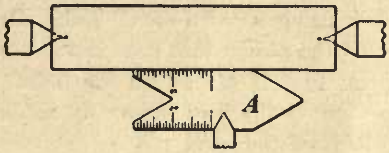

Fig. 3.

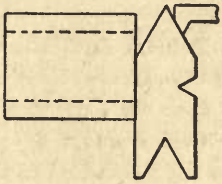

Fig. 4.

38. Centre Gauge. — In Fig. 3, *A* represents a centre gauge and gauge for grinding and setting a V-thread tool; the angles of this gauge are 60°. Care should be taken to grind the tool to fit the gauge; the tool should be given top rake enough to make it cut clean, and only enough bottom rake to clear well and not rub against the thread.

How to Set a V-Thread Tool. — Fig. 3 represents a piece of work held between the centres of a lathe. Applying the gauge as shown in the figure, the V tool can be set at right angles to the work and then fastened in place.

Height of Tool. — Set the point of the tool at the same height as the points of the lathe centres.

39. Stop Gauge. — With the cross-feed screw run the tool in until the point touches the work, then put on and adjust the stop which regulates the depth of the cut.

40. Pitch. — The pitch of a thread is the distance between the centres of two threads.

Threads per inch signifies the number of threads contained in one inch, measuring at the root of a V thread and at the right edge of a square thread.

41. Index. — With each lathe there is a screw-cutting index, giving the number of " threads per inch " that can be cut on the lathe, and the change gears used in cutting the same.

The first column of figures represents the number of threads per inch; the second column, the number of teeth on the gear used on the "feed spindle"; the third column, the number of teeth on the gear used on the lead screw.

On any of the shop lathes you will have to consider only the gear on the lead screw and the gear on the feed spindle; the intermediate gear can be of any size that will connect them.

For example: if it is desired to cut a screw of "thirteen pitch" (thirteen threads to one inch), find thirteen in the first column; the numbers opposite in the second and third columns are 96 and 78 respectively. Place a gear with 96 teeth on the feed spindle, and a gear with 78 teeth on the lead screw, and adjust the intermediate gear to the same.

42. Putnam Lathe. — When using a "Putnam" lathe, always disconnect the carriage by dropping the pinion that runs in the rack, which can be done by loosening a nut that is placed on the outside of the apron; then connect the carriage to the lead screw by means of the "clamp nut" attached to the back of the carriage.

43. The Brown & Sharpe and Pratt & Whitney lathes have the lead screw and feed shaft combined in one. In this case simply throw in the "clamp nut" by turning the small crank handle that is located on the lower part of the apron, right-handed. Be sure with these lathes that the traverse feed is out.

Speed. — On work one inch and less in diameter use the first speed "out of gear," at least as slow as that until you can manage the lathe properly.

Oil. — Use lard oil on steel and wrought iron, but not on cast iron.

44. To cut a right-hand screw, begin at the right-hand end of the work and cut towards the left. The first time over just allow the point of the tool to touch the work sufficiently to "line out" the thread; then lay a scale on the work and count the threads per inch to see if the pitch is right

With one hand on the handle of the cross-feed screw run the tool back far enough to clear the work; with the other hand reverse the lathe until the tool is traversed to the end of the work; then feed in and take another cut. The cuts at first can be quite heavy, but as the thread approaches its finished size they should be very light. The depths of the cuts are regulated by means of the stop screw, which is adjusted while running the carriage back.

Fitting the Thread to the Nut. — When the top of the thread gets nearly sharp, take the work out of the lathe and try the nut on it to ascertain if it fits; if it does not, take another cut and try again, continuing until the thread will fit the nut. This applies to a sharp **V** thread only.

45. Left-Hand Thread. — In cutting a left-hand thread, gear the same as in cutting a right-hand thread, with the exception that the feed motion has to be reversed. On a "Putnam" lathe this is done by means of two intermediate gears; on a "Brown & Sharpe" or a "Pratt & Whitney" lathe, it is done by means of a lever on the headstock.

To cut a left-hand screw, begin at the left and cut to the right. At the beginning of the thread it will be best to cut a recess as deep as the thread to start the tool from. With these few exceptions, the operation is the same as in right-hand thread cutting.

46. Inside Thread.—Most of the operations in inside thread cutting, such as "gearing up" the lathe, adjusting the height of the tool, etc., are similar to outside thread cutting.

If the work is cast iron, the hole should be bored or drilled large enough to allow only three-quarters of a full thread; that is all that is necessary on a **V** thread with cast iron, unless the thread has to be steam tight.

The Manner of setting the Tool is shown in Fig. 4 (p. 19). The work is supposed to be held in a chuck, the hole either drilled or bored to the required diameter, and the end "squared up." By applying the gauge as shown, the tool can be set at right angles to the work axis.

Stop Gauge. — To regulate the depth of each cut, the collar on the stop screw must be on the inside of the clamp, and the screw must be turned in the direction opposite to that used in outside thread cutting.

Oil.—Use lard oil on steel and wrought iron, but not on cast iron, except it be necessary to run a tap through the hole to size it, when oil may be used.

CHUCKING.

47. Chucks are devices for holding work or tools, and are made of various sizes.

Independent Chucks are those in which each jaw is moved separately.

Universal Chucks are those in which the jaws move simultaneously to grip or release the work.

Combination Chucks are those in which the jaws may be moved independently or simultaneously.

Small universal (or drill) chucks, although mainly used to drive drills, may also be used to drive very small work that is to be chucked or turned.

When asking for a chuck at the tool room, be sure and give the swing and make of the lathe you desire to use it on. (The swing of a lathe is twice the distance from the centre to the nearest point on the bed.)

48. To put the Chuck on the Spindle, remove the live centre and plug the hole with clean waste; then take off the face plate by turning

its top towards the front of the lathe; start it off by means of a tangential blow of either a lead hammer or a block of wood. See that the thread in the chuck and on the spindle is free from chips and grit; put a little oil on the spindle thread; then hold the chuck in the right hand, and with the left rotate the spindle slowly by means of the belt until the chuck comes to the shoulder on the spindle. Do not force a chuck or a face plate on to the spindle of a lathe, as each should go on freely; if they do not, there must be a cause; it may be chips in the thread. In any case, the cause should be found and removed.

Direction of Chucking. — Work that has to fit a shaft of any kind should be chucked in the same way that it has to go on the shaft.

Pulleys. — If it be possible, when chucking a pulley, place each spoke opposite a jaw to receive the strain. The jaws must be "set up" tight enough to keep the work from shifting.

49. "Truing up" Work in an Independent Chuck is accomplished by placing the work in the chuck and setting the jaws against it tightly enough to keep it in position; run the lathe at a high speed; with the hand resting on the carriage, hold a piece of chalk so that it will just touch the work, then stop the lathe, and if the chalk has touched all around the work, it is "true"; but if the chalk has only touched a part, loosen the jaw, or jaws, opposite that part, and set the others in; rub the chalk mark out and try again, continuing until the work runs true.

Card 105. — To get good results, the pulley (Card 105) should be "trued up" from the inside of the rim.

50. "Truing up" Work in a Universal Chuck. — Place the work in the chuck, "set up" the jaws by means of one screw, then run the lathe at a high speed, and use chalk as before; if it does not run true enough, loosen the jaws and turn the work about one-quarter of a revolution, then "set the jaws up," and try it again; when right, tighten all the screws.

51. The Tools used in chucking are the drill rest, the chucking drill, and the chucking or flat reamer. Hand reamers are of standard diameter, and are used by hand, with the work held in a vise. Chucking reamers should be from three to five thousandths inches smaller than the hand reamer, and the drill should be at least $\frac{1}{64}''$ smaller than the chucking reamer.

52. Manner of setting a Drill Rest. — Fasten the drill rest in the tool post, as shown (plan view) in Fig. 5.

The centre of the slot should be at the same height as the lathe centres. To insure this, run the dead centre into the slot, and adjust the drill rest by means of the elevating and cross-feed screws, until the centre just touches the top and bottom edges simultaneously, and is in the

centre of the slot lengthwise (approximately); then traverse the carriage until the drill rest is within $\frac{1}{2}''$ of the work.

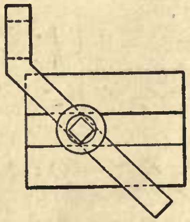

Fig. 5.

Oil should be used on steel and wrought iron, but not on cast iron.

Speed. — For a $1''$ drill, run on the second speed, and for a $\frac{1}{2}''$ drill, on the third speed.

53. Starting the Drill. — Place the drill in the slot, with its point against the centre of the work (as near as the eye can locate), and the other end on the dead centre. Start up the lathe, hold the drill firmly in the slot with a monkey-wrench, and feed in until it cuts to about half the depth of its point; then loosen your hold on the monkey-wrench, and feed in quite rapidly. If the drill moves sidewise, the hole is not true; this being the case, again hold the drill firmly with the monkey-wrench, and feed in slowly until the side of the hole that runs out is cut away; then loosen your hold on the monkey-wrench, and feed in as before. If the drill does not move sidewise, it is central, and the hole is true. This "truing up" must be done before the drill cuts to its full diameter.

When the Drill begins to break through, hold it on the dead centre; when through, stop the lathe and take out the drill; next put a chucking reamer through, using a monkey-wrench to steady it while starting.

54. How to use a Hand Reamer. — Hold the work in a vise, and ream through the same way that it has to fit on the shaft. Use oil on steel and wrought iron, but not on cast iron, except a little on the shank of the reamer. Always turn a reamer forward and bear down on it lightly, but *never under any condition turn it backward.* Hand reamers should be used very carefully.

ARBORS.

55. An arbor or mandrel is a cylindrical piece which is forced or driven into hollow work in order to furnish centres upon which to revolve it. For example: a pulley having been chucked and hand-

reamed requires an arbor to be driven into it in order to supply centres to hold it while it is turned in the lathe. Arbors are usually made of cast steel, especially when small.

56. How to use an Arbor. — Rub a little oil on the arbor, put the small end in the hole the same way that it was reamed; then, with a copper hammer, drive in the arbor tight enough to prevent the work from slipping.

57. How to make a $\frac{1}{2}''$ Arbor. — (1) A good quality of cast steel should be used in making this arbor. (2) It should be annealed, then carefully centred and "squared up" to the required length with a side tool. (3) A portion of the ends should be turned to within $\frac{1}{64}''$ of finished size, using a diamond-point tool. (4) A small recess should be formed with a side tool, about the countersinks (as shown on card), to prevent the edges of the countersink from being injured when the end of the arbor is struck. (5) See that the countersinks are of the given diameter. (6) Turn the reduced portion to the required diameter and file sufficiently to erase the tool marks, running the lathe at a high speed and using an 8″ "mill bastard" file; also slightly round the corner of the ends with a "graver." (7) Polish the reduced portion and the ends, except the countersinks, using a speed lathe. (8) File a flat place on the reduced portion of the ends (as shown on card) to receive the set screw of the lathe dog; use an 8″ "hand smooth" file and finish with emery cloth. (9) Turn the main body of the arbor to within $\frac{1}{64}''$ of finished size; file a flat place on the end (as shown on card) and stamp the diameter of the arbor there, using a **V** block to hold the arbor and $\frac{1}{16}''$ figures for stamping. Not until all the foregoing operations have been performed is the arbor ready to be hardened. Use oil in drilling and countersinking.

Speed and Top Rake. — Remember that the stock is cast steel, and the cutting speed should be less than on the same diameter of machinery steel, and that the diamond point and side tool should have a top rake of about 20°.

Round Corners. — In turning off the reduced portion do not leave a square corner, which would be very liable to cause cracking in hardening.

The $\frac{1}{64}''$ left on the main part is to be ground off after hardening.

CYLINDRICAL GRINDING.

58. Grinding machines are employed to finish work more smoothly and much more accurately than can be done with steel cutting tools. They are very useful, as they can be made to operate on hardened as well as soft work and produce the same degree of accuracy.

Cylindrical and surface-grinding machines are not designed to remove a large amount of stock, but simply to reduce the work surface to true and exact dimensions.

They operate on essentially the same principle as the engine lathe, the steel cutting tools of the engine lathe being replaced by a rapidly revolving emery wheel, driven by an independent drum or wide pulley. Therefore, if the engine lathe is well understood, there will be no difficulty in understanding the grinding machine after a brief examination.

Motion of Work. — In all cases the motion of the work must be in a direction opposite to the wheel at the cutting point.

The Speed of the Work can be regulated as on an engine lathe, high speed being used for small, and slow speed for large, diameters.

The Speed of the Emery Wheel should be about 5000 feet per minute.

59. Emery Wheels. — No definite rule can be given by which emery wheels may be selected for different kinds of work; much depends on the nature of the work. No. 60 emery will give as good results on hardened work as No. 90 will on soft work. When a large amount of stock has to be ground off, it is best to use about No. 40 for roughing and No. 120 for finishing. Where one wheel is used for both roughing and finishing, and there is only a small amount of stock to be ground off, it will be profitable to use about No. 100 emery.

The degree of coarseness of emery wheels is denoted by the "number" of the emery used in their composition. See § 65.

60. Care of Grinding Machines. — The wearing surfaces should be well oiled and all parts kept as clean as possible; for if emery gets into the bearings, the machine soon becomes unreliable and short-lived for accurate work. Any emery grinder requires great care to keep it clean.

True Centre Holes and Centres are absolutely necessary to obtain good results when the grinding is done on centres.

Relieve the Dead Centre. — In grinding, the work becomes heated and expands, thus binding on the dead centre; therefore be sure that the work is kept free, by frequently relieving and oiling the dead centre.

61. Arbor Grinding. — The following method is adopted in grinding a $\frac{1}{2}''$ arbor. The arbor is supposed to be marked, hardened, and tempered, and the diameter $\frac{1}{64}''$ large. Get the special "dog" from the tool room and fasten it on the marked end of the arbor, take a light cut over its entire length, then caliper both ends with a micrometer caliper (see § 67); the large end (which is the marked end) should be about four thousandths larger than the small end; if it does not caliper as required, adjust the machine until it will grind the proper taper.

Light Cuts. — To produce a true surface, it is necessary to take a very light cut as the work approaches its finished size, which is five

hundred thousandths of an inch one inch from the small end. In this case the arbor should fit the $\frac{1}{2}''$ hand-reamed hole in the pulley, so that the pulley will drive about half way on the arbor.

Cuts may be taken both ways, but always commence at the small end to take the finishing cut, so that you can get the size of that end.

General Suggestions. — It must be remembered that to get good results on work even as simple as an arbor, (1) the final cut must be very light; (2) that you must not take a cut over its entire length and then caliper; but take a cut of about $\frac{1}{4}''$ in length, then stop the machine and caliper, or try it in the pulley; (3) that to caliper work on centres, the caliper is put over the work and adjusted by means of the knurled head until the friction slips, the reading being then taken; (4) that you must put a collar under the hub of the pulley when driving the arbor into it, in order to prevent breaking the arms.

PULLEY TURNING.

62. Parts Finished. — Every part of the pulley drawing that is marked *f* must be finished; that is, turned, filed or scraped, and polished.

To be remembered. — (1) That this pulley is quite slender; therefore, do not take a heavy cut or a coarse feed. (2) That all parts marked *f* must be roughed out before any part is finished.

Speed. — Use the third speed, "back gears in," for both roughing and finishing cuts on the face and edges of the rim. For both roughing out and finishing the hub, use the third speed, "back gears out."

Feed. — Use fine feed on both roughing and finishing cuts.

Tools. — To turn off the face, both roughing out and taper, a diamond-point tool is employed with a top rake of about 20° and the point slightly rounded.

To turn off the hub, a round-nosed tool is employed for both roughing and finishing cut.

To "square up" the rim and the end of the hub, a round-nosed tool is employed for the roughing cut and a facing tool for the finishing cut.

63. Order of Operations. — (1) Turn off the face of the pulley to the given diameter, $4\frac{7}{8}''$, which may require more than one cut. (2) Turn off the hub to within $\frac{1}{64}''$ of the required diameter. (3) "Square up" the rim and the ends of the hub to within $\frac{1}{64}''$ of the required size, by clamping the carriage and feeding the tool from circumference to centre. (4) Take the finishing cut on the rim and the sides of the hub, by clamping the carriage and feeding the tool from centre to circumference.

(5) Take the finishing cut on the hub. (6) The taper on the rim is $\frac{1}{4}''$ in $5''$; the arbor being $5''$ in length, set the dead centre out of line $\frac{1}{8}''$ toward the back of the lathe. Rub chalk on the face of the pulley, and with a pair of dividers draw a line midway between its edges; set the diamond-point tool so that it will just touch at this line and feed the tool toward the headstock. It is obvious, that to taper the second half, the simplest way is to reverse the pulley in the lathe and employ the tool as on the first half. (7) Run the lathe at the second speed, "back gears out," and with an $8''$ "mill bastard" file erase the tool marks on the face of the pulley. (8) Set the side tool at an angle of about 45°, run the lathe at a slow speed, and make a small chamfer on the inside corner of the rim, the object being to true up the inside edge of the rim. (9) Put the pulley in a speed lathe, run it at the third speed, scrape the hub and round its corner by means of the "graver." If all the foregoing operations have been carefully performed, the pulley is now ready to be polished.

POLISHING.

64. The Process of polishing in a Lathe, it should be remembered, reduces to some extent the size of the work; the amount, though small, is yet of importance where exact dimensions are necessary.

Operations Preparatory to polishing. — When it is required to polish and keep the work as true and parallel as possible, it should be finished very carefully with lathe tools, file, and scraper; for if it requires much application of emery to obtain the necessary polish, the surface will not be smooth and true, as the emery cuts out the most where the metal is most porous.

If a piece of work is to be polished, the finishing cut should be taken with a fine feed, and at as quick a cutting speed as the hardness of the metal will permit. With fine feed and quick speed, the pores of the metal do not show; whereas with coarse feed the pores are exposed for quite a depth.

Filing. — If cylindrical, the surface should be filed enough to erase the tool marks, using a "mill bastard" file for that purpose.

Scraping. — If radial, or of curved outline, the surface should be scraped with a well-oiled stone hand scraper, with a piece of leather between it and the rest to prevent the scraper from chattering; the scraper should be used at as fast a speed as it will stand.

65. The "Number" of Emery. — Emery derives its graded "number" from the number of meshes to the inch in the silk sieve through which it is sifted. For example, emery that would pass through a sieve having six meshes to the inch, and over one having eight meshes, would be called No. 6 emery.

Grade of Emery used on Different Kinds of Work. — For ordinary work that has been filed or scraped very carefully, use Nos. 60, 90, 120, and flour-emery cloth, in the order given, with lard oil, revolving the work at a very fast speed. The emery cloth should be wrapped closely around a piece of wood. To afford a fulcrum for the wood, the T rest should be placed a short distance from the work.

If the work is finished very carefully, it may not be necessary to use No. 60 emery cloth; No. 90, or even finer, may be coarse enough to remove the file or scraper marks.

The coarse grade should be used until all the file or scraper marks are removed, each successive grade being employed until it has entirely removed the marks left by the grade previously used. The emery should be moved backwards and forwards along the work when polishing cylindrical surfaces, so that the marks will cross and recross each other.

66. The Final Polish is given by flour-emery cloth, moved along the work very slowly and under a light pressure.

On a Radial Face, the emery cloth should be moved continuously, so that it will approach and then recede from the centre of the work, the object of this being to prevent the emery from cutting rings into the surface.

The emery cloth should be changed in position as the emery wears off, thus bringing all parts in contact with the work.

MICROMETER CALIPER.

67. Directions for reading a Micrometer Caliper. — The work to be measured is introduced between the points of the screws *A* and *C*, Fig. 6,

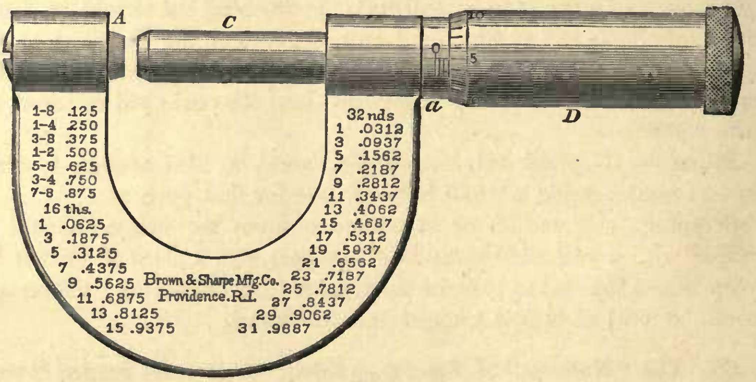

Fig. 6.

the distance between which is readily adjusted by turning the thimble *D*, which is connected with the screw *C*. The screw has forty (40) threads per inch; therefore, every turn of it will open the caliper twenty-five thou-

sandths of an inch (.025″). The number of turns the caliper has been opened is indicated by the scale on the hub a, which is graduated forty (40) divisions to the inch, and the fractional part of a turn (or its equivalent in thousandths) is indicated by the scale on the thimble D, which is graduated into twenty-five (25) parts. Hence, to read the caliper, count the number of whole divisions on the scale of the hub at a, and multiply by twenty-five (25) ; then add the number of divisions counted on the scale of the thimble D. The result will be the distance between the screw points in thousandths of an inch.

For example : as set in the figure there are three (3) whole divisions visible on the scale at a, which gives us $3 \times 25 = 75$. Then we read five (5) divisions on the thimble D, which, added, gives us $3 \times 25 + 5 = 80$, eighty thousandths of an inch (.080″).

Note.—On some micrometer calipers the screw C has fifty (50) threads per inch ; hence every turn of it will open the caliper twenty thousandths of an inch (.020″), and the scale of the thimble D is graduated into eighty (80) parts, each part indicating one four-thousandth of an inch or twenty-five hundred-thousandths (.00025″).

On micrometer calipers not having a frictional connection between the screw and the knurled head, care should be taken in adjusting. The hold on the knurled head should be easy, so that the "feeling" will indicate when contact is made. This feeling being the same each time the caliper is used, the readings will be comparative.

68. Table of Common Fractions and Decimal Equivalents.

$\frac{1}{64}$	–	–	–	.015625	$\frac{33}{64}$	–	–	–	.515625
–	$\frac{1}{32}$	–	–	.03125	–	$\frac{17}{32}$	–	–	.53125
$\frac{3}{64}$	–	–	–	.046875	$\frac{35}{64}$	–	–	–	.546875
–	–	$\frac{1}{16}$	–	.0625	–	–	$\frac{9}{16}$	–	.5625
$\frac{5}{64}$	–	–	–	.078125	$\frac{37}{64}$	–	–	–	.578125
–	$\frac{3}{32}$	–	–	.09375	–	$\frac{19}{32}$	–	–	.59375
$\frac{7}{64}$	–	–	–	.109375	$\frac{39}{64}$	–	–	–	.609375
–	–	–	$\frac{1}{8}$	.125	–	–	–	$\frac{5}{8}$	.625
$\frac{9}{64}$	–	–	–	.140625	$\frac{41}{64}$	–	–	–	.640625
–	$\frac{5}{32}$	–	–	.15625	–	$\frac{21}{32}$	–	–	.65625
$\frac{11}{64}$	–	–	–	.171875	$\frac{43}{64}$	–	–	–	.671875
–	–	$\frac{3}{16}$	–	.1875	–	–	$\frac{11}{16}$	–	.6875
$\frac{13}{64}$	–	–	–	.203125	$\frac{45}{64}$	–	–	–	.703125
–	$\frac{7}{32}$	–	–	.21875	–	$\frac{23}{32}$	–	–	.71875
$\frac{15}{64}$	–	–	–	.234375	$\frac{47}{64}$	–	–	–	.734375
–	–	–	$\frac{1}{4}$	.250	–	–	–	$\frac{3}{4}$	.750
$\frac{17}{64}$	–	–	–	.265625	$\frac{49}{64}$	–	–	–	.765625
–	$\frac{9}{32}$	–	–	.28125	–	$\frac{25}{32}$	–	–	.78125
$\frac{19}{64}$	–	–	–	.296875	$\frac{51}{64}$	–	–	–	.796875
–	–	$\frac{5}{16}$	–	.3125	–	–	$\frac{13}{16}$	–	.8125
$\frac{21}{64}$	–	–	–	.328125	$\frac{53}{64}$	–	–	–	.828125
–	$\frac{11}{32}$	–	–	.34375	–	$\frac{27}{32}$	–	–	.84375
$\frac{23}{64}$	–	–	–	.359375	$\frac{55}{64}$	–	–	–	.859375
–	–	–	$\frac{3}{8}$	.375	–	–	–	$\frac{7}{8}$	.875
$\frac{25}{64}$	–	–	–	.390625	$\frac{57}{64}$	–	–	–	.890625
–	$\frac{13}{32}$	–	–	.40625	–	$\frac{29}{32}$	–	–	.90625
$\frac{27}{64}$	–	–	–	.421875	$\frac{59}{64}$	–	–	–	.921875
–	–	$\frac{7}{16}$	–	.4375	–	–	$\frac{15}{16}$	–	.9375
$\frac{29}{64}$	–	–	–	.453125	$\frac{61}{64}$	–	–	–	.953125
–	$\frac{15}{32}$	–	–	.46875	–	$\frac{31}{32}$	–	–	.96875
$\frac{31}{64}$	–	–	–	.484375	$\frac{63}{64}$	–	–	–	.984375
–	–	–	$\frac{1}{2}$	.500	–	–	–	1	1.000000

SQUARE-THREAD CUTTING.—CARD 116.

69. Square-Thread Tool.—For cutting square threads the tool shown in Fig. 9 is employed.

Inclination of the Tool.—The sides of the tool *AB* and *EF*, Fig. 7, should be inclined to the body of the tool, the degree of inclination depending upon the pitch of the thread to be cut.

The Method of finding the Degree of Inclination is shown in Fig. 8. Draw the lines AD and AB at right angles to each other. Make the distance AB equal to the root circumference, and AC equal to the

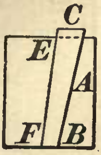

Fig. 7.

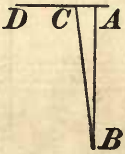

Fig. 8.

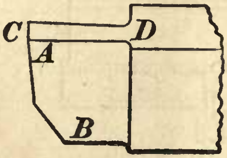

Fig. 9.

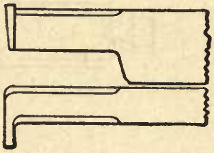
Fig. 10.

pitch of the thread to be cut: draw BC; then the angle BCD will be the angle which the root of the thread makes with the axis of the work, and the angles of the sides of the tool should differ from this sufficiently to give the necessary clearance.

The tool should be somewhat narrower at D and B, Fig. 9, than at C, so that the cutting may be done by the edge C entirely.

Finishing Tool. — The width of a finishing tool at C should be exactly one-half the pitch. For example, if the thread to be cut is six (6) pitch, the width of the tool at C should be one-twelfth of an inch ($\frac{1}{12}''$).

Roughing Tool. — When it is necessary to use a roughing tool, make the width at C about one hundredth of an inch (.01″) less than the finishing tool.

Coarse Pitch. — For a very coarse pitch the tool is made about one-half the width of the thread groove, and a groove is cut on the work; the tool is then moved laterally and a second cut is taken. The right- and left-hand side tools are then employed to finish the sides of the thread.

70. Inside Square-Thread Cutting. — Fig. 10 represents an inside square-thread tool. The inclination is found by the same method as employed with the outside tool. As this tool is necessarily rather slender, the cuts should be light.

Top Rake and Oil. — Square-thread tools, when employed upon wrought iron and steel, should have some top rake, and be freely supplied with lard oil.

Filing up Tools. — Use an 8″ "hand smooth" and a "dead smooth" file to file up the tools, and a micrometer caliper to measure the width.

Outside Thread. — In Fig. 11 the manner of setting a square-thread tool for cutting outside threads is illustrated.

Inside Thread. — In Fig. 12 the manner of setting an inside square-thread tool is shown. The work is supposed to be held in a chuck, the hole bored to size, and the end "squared up."

71. The Nut. — The stock for the nut is held in the jaws of a chuck and "trued up," and a $\frac{13}{16}''$ hole chucked through it; then a boring tool

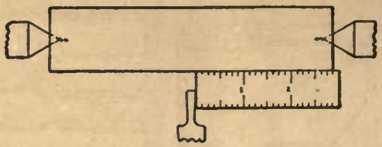

Fig. 11.

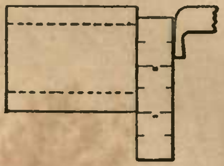

Fig. 12.

is employed to bore it to the required diameter, which should be about .01″ larger than the diameter of the tap measured at the root of the thread; a thread is now cut in it, with an inside roughing tool, to nearly the diameter of the tap; it is then held, in wooden clamps, in a vise, and first tap No. 1, and then tap No. 2, is run through it. (Oil should be used freely in tapping.) Now it should be screwed on a nut arbor, "squared up" to the required length, and turned to the given diameter. A facing tool is used in taking the finishing cut on the ends.

72. Cutting the Thread on the Shaft. — With the roughing tool take a cut on the shaft to the required length of thread; then remove it from the lathe and drill a hole at the termination of the thread, equal in diameter to the width of the finishing tool, and in depth to the depth of the thread. The lathe should be stopped when the tool is near this hole and the cut continued to the hole, running the lathe (by pulling the belt) by hand. The finishing tool should be set so that it will cut on both sides of the groove.

The Depth of the Thread should be a little greater than the width of the finishing tool, in order to give the necessary clearance.

Trying the Nut on the Shaft. — Before the nut is tried on, about two threads should be turned off the end of the screw (as shown on the card) and the burr filed off the tops of the thread.

73. Knurling. — A knurling or milling tool is employed to make indentations upon cylindrical surfaces, which are required to be turned by hand in order to prevent slipping. Knurling is represented on the card by crossed lines.

Method of using the Double Knurls. — The holder is placed in the tool post at right angles to the surface to be knurled, and the two hardened wheels are forced against the work with considerable pressure; the carriage is then slowly traversed along the work until the pyramidal projections produced are brought to a point.